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WATER IRRIGATION OF COFFEE FARMERS IN DAK NONG PROVINCE, CENTRAL HIGHLAND OF VIETNAM

PHAN THANH DINH, NGUYEN THI PHUONG CHAU & LE THANH HOA

Vietnam National University, University of Social Sciences and Humanities,

Faculty of Geography, Ho Chi Minh City, Vietnam

ABSTRACT

The increasing of global coffee demand has led the coffee boom in Vietnam. The Central Highland is the main coffee area of Vietnam. DakNong has coffee land rapid expansion recent years. More immigrants come that share small land of farming. Farmers trended to enhance more fertilizer and water irrigation to have more yield and they resulted in problems on land and water resources. The special typology and climate drive farmers to overuse water usage for their coffee farms in the study area. Lacking of water supply, farmers irrigated more fresh water from rivers. And with the unpredictable of climate change, the prolonged dry season causes exhausted water on ponds and irrigation dams and less water on the river branches; that drive farmers exploiting the ground water for irrigation. The results from the study also showed the location where the irrigation system had developed, farmers trended to apply the water usage as the technical advisement. Other areas without irrigation dams, farmers overuse water from the rivers, even four times higher than the technical advisement. This study expected to have the proper irrigation supports for farmers to have better management on water resource in this province.

KEYWORDS: Coffee Plantation, Water Usage, Water Irrigation, Climate Changes & Farmers' Awareness of Water Resource

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Original Article

INTRODUCTION

Coffee becomes a popular beverage worldwide. Global coffee demand in consuming countries is increasing while coffee products from producing countries are continuing tightening, that made coffee boom in Vietnam (Dang & Gerald, 2008). And in recent years, Vietnam has become the second rank of coffee export (by ICO, 2016&2017; USDA, 2015a&2016a). The Central Highlands (included four provinces of DakLak, Lam Dong, DakNong and Gia Lai) are the main coffee areas of Vietnam covered ninety percent of total national coffee area (MARD, 2012). In which, DakLak has a long term of coffee growing, and DakNong has many new coffee areas. Amongst the coffee areas, DakNong is the third large coffee area of Vietnam, after DakLak and Lam Dong (See Figure 1).

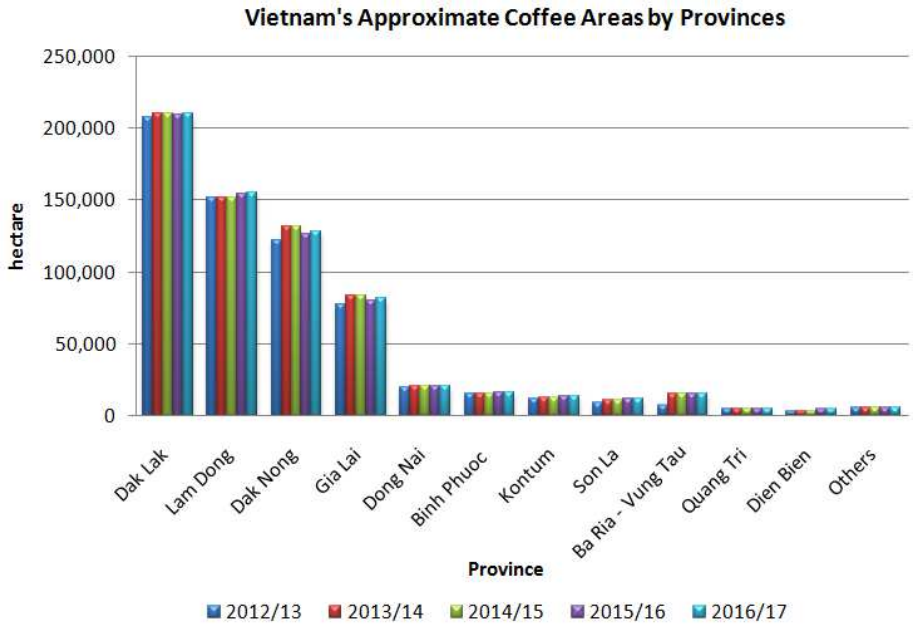

Figure 1: Vietnam's Approximate Coffee Areas by Provinces in Recent Five Years

Source: USDA (2014, 2015b & 2016b)

Along with the coffee expansion, water using for irrigation is rapidly increasing. The climate change drives more difficult situations with increasing temperature and longer dry season and impacts on coffee flower booming period; that requires more water irrigation for crop. This research targeted on the water using for coffee planting by farmers in DakNong province of Central Highland in South Vietnam to analyze the farmer's accessibility on water resource to their farms and crops. And these have some impacts on water resource.

RESEARCH METHOD AND DATA COLLECTION

To understand the water using for coffee farming in this province, primary data was gathered from household questionnaires on 311 coffee farmers in the communes of districts, where coffee farms are concentrated and most supported by the water sources. The primary data explained the main inputs of coffee supply chain and the changing of climate related to the water usage, the times of irrigation, and the irrigation schedule of farmers in a year crop. These depend much on farmers' perception on resources, climate, and crop production.

The secondary data collection is about the base map of province and river catchment of the selected areas; the guidelines for robusta coffee plantation by to compare the water usage guideline to the irrigation practice; the fertilizer using was also mentioned in this comparison. The coffee planning and strategies and irrigation development of government at levels were also gathered to understand the government supports to farmers for their farming and to the water resource protection.

Primary data was mainly analyzed through the SPSS statistical tool for the above discussions. The GIS tool was to identify the farming areas and the distances of water sources to the farm lands in the selected areas of the province. From these distances of water sources, the SPSS tool supported to understand ways the farmers access water for irrigation. And the stepwise linear regression supported to understand the water application for coffee of farmers.

DISCUSSIONS

Conditions for Coffee Farming in Daknong Province

DakNong Province had been separated from DakLak Province since 2003, located in the southwest of Central Highlands, and has suitable climate for perennial industrial trees and other industrial crops[1]. The average elevation is about 600m to 700m; some areas reach to 1,982m. Its terrain is low down from the East to the West, the same directions to the main river systems. There are two main river systems in this province: (1) the Srepok river is in the Northwest and its various stream branches run through the northwest districts; (2) the Dong Nai river runs from the North to the South and supplies water for most of the South districts.

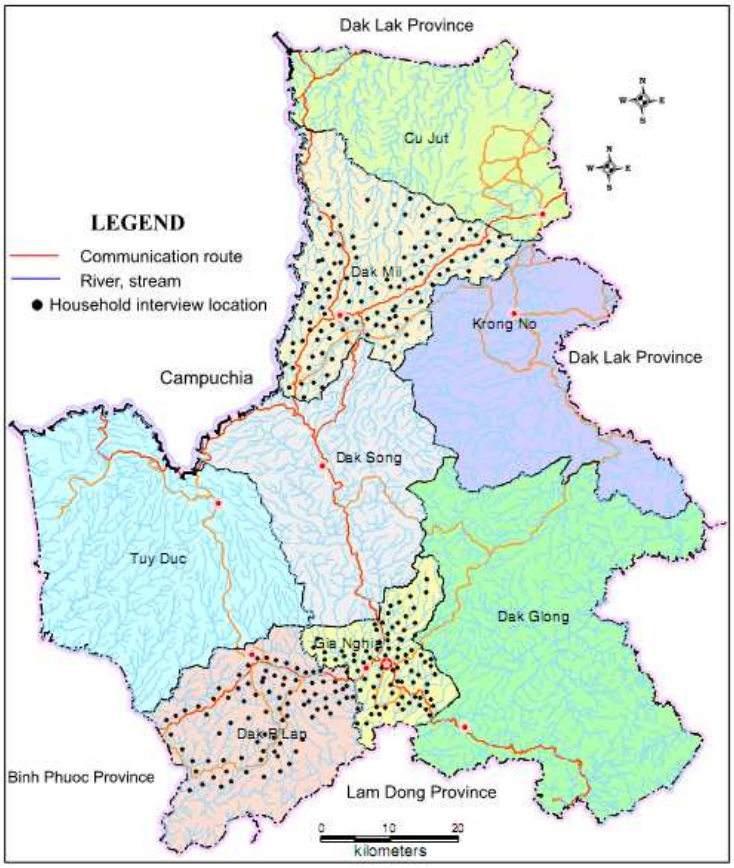

Figure 2: Map of Study Areas and River Catchments in Daknong Province

Source: Developed from the DakNong base map by authors

The rain season receives most of rain water of a year, about nighty percent; while the scarcity of rain in the dry season. The annual average rainfall is 2,513mm; the highest level is 3,000mm most in August and September. The annual driest months are in January to February. This is the time farmers have more irrigation for their coffee. The province is in the upstream areas, though it has very high rainfall, all streams are small and narrow and cannot store much water during rain season. It has caused the problems of irrigation in the dry season.

[1]The following discussion about natural condition of DakNong province was gathered from the he internet portal of DakNong People's Committee http://eng.daknong.gov.vn/Introdution/Pages/NaturalConditions.aspx

Coffee is one of the important crops in DakNong, along with pepper, cashew, and fruit trees, etc. Since coffee demand has been increasing, many farmers transformed their plantation to coffee farming. However, coffee needs a quite amount of water. In Central highland, one coffee hectare requires 2,200 to 2,400 cubic of irrigation water per crop in a normal climate (MARD, 2001). In the crisis climate such as longer dry season, it needs more water. Therefore Coffee is planned to cultivate near the water source. In DakNong, most coffee areas are planted in districts supported by the above two river catchments (MARD, 2012 &DakNong People Committee, 2016). However, the irrigation system in this province is not well developed. Many agriculture areas did not reach to this system yet and some others have degradation or very old (DARD, 2014). The selected areas in this study are chosen in Dak Mil district, where the system just partly supports for agriculture area; and two others are in DakR'Lap district and GiaNghia town, where this system has better supported (See Figure 2).

Coffee Farming and its Efficiency Investment to Farmers

DakNong has high amount of migration from other provinces since the government planned their land for some national projects. In 311 selected farmers, 88 percent of them have lived DakNong within 20 years, the period of huge immigration flows to this province. They come for farming and made land price increase. The new comers purchased the small land for their farm. There are about 48 percent of farmers cultivated in 1 or less than hectare. More than 76 percent of farmers have their farm less than 2 or equal 2 hectares. But the average farm sizes in three selected areas of GiaNghia, DakR'Lap and Dak Mil are 1.6; 1.9; and 2.1 hectares, respectively. This means less farmers cultivated in the large farms and most of them live more than 30 years in this province. However these lands are not totally for coffee. Farmers save some for other cultivation (such as cashew, pepper, fruit tree, or short-term industrial plants, etc.). Because of the market instabilities of agricultural products, farmers have trended to cultivate more than one product to ensure their income. Most of the small-land farmers with equal or less than 1 hectare used their all lands for coffee (included 172 farmers, 55.3 percent). There were 95 farmers (30.5 percent) cultivating coffee in areas of equal or less than 2 hectares. In total, about 85.8 percent of farmers had their farm sizes equal or less than 2 hectares. And the average farm size of the selected farmers was 1.5 hectares.

The average coffee density was ranked from 970 to 1,100 trees per hectare, where DakMik had the highest density with average 1,100 trees per hectare and DakR'Lap had the lowest. Comparatively, the average yield was the highest in Dak Mil with 3.2 tons per hectare; GiaNghia was 3.0 tons per hectare the same with the average yield of total area; and the average yield in DakR'Lap was lowest with 2.7 tons per hectare. In analyzing the marginal efficiency of investment in coffee farming, the result was positive to farmers[2]. All farmers got this ratio larger than zero. The average ratio was 3.4; the highest ratio was 9.7 and the lowest was 0.3. Only three farmers got the ratio of 0.3 to 0.5, because they did not use fertilizer or chemical and water for the crop, just rain water in rainy season.

The technical guideline to coffee density was about 1,000 to 1,100 coffee trees per hectare to have 2.5 to 3.0 tons per hectare. This was nearly the same as in practice, however; farmers trended to crop with higher density. Some farmers in DakMik and DakR'Lap have croped their coffee with 1,200 trees per hectare. Some farmers in GiaNghia have croped with 1,500 to 1,900 trees per hectare. And their yields were up to 5.0 to 7.0 tons per hectare. To have these yields, farmers used

[2]The marginal efficiency of investment is the ratio between the total net incomes to the total cost for coffee in one hectare per crop. It tells when investing 1 currency unit for coffee, farmer receives the amount of currency units in one hectare per crop.

more fertilizers and chemical added and specially, more water for their crops.

Fertilizer Inputs for Coffee Farming of Farmers

After harvesting the previous crop, land needs one month to recover and then come to the first fertilizer application for the new crop. The main fertilizer for coffee is N,P,K. It is applied for coffee during dry season along with irrigation. In technical advisement (MARD, 2001), N,P,K are applied four phases with irrigation along with four growth stages of coffee during dry season. The first phase is for branches; the second phase is to prepare for flowering; the third is for having fruits; and the last is for growing fruits before harvesting. The second is organic fertilizer guided to be applied one month before starting the new crop of every two years. The portion of each N,P,K is required different usage at each phase. In the researched area, according to the guideline, there were 49 percent of farmers overused N,P,K every phase; 10 percent of them had the usages 2 to 4 times higher. Two of them applied N,P,K five phases instead of four as the guideline.

The organic fertilizer was applied every year in these study areas. This is applied one month after the previous crop in guidelineand two years for one time. In practice, most of farmers used the same or less than guideline usage, not only one time per year, but every time after N, P, K applied (at least four times per crop). Some farmers (4 farmers in DakR'Lap and GiaNghia) applied 5 to 6 times per year. The overuse of fertilizer has caused problems with coffee production, nutrient losses, and in the long time ruined the environment. And specially, it wastes the fertilizer inputs (Winston *et al.*, 2005).

Water Source and Water Irrigation

As discussed above, that DakNong has very high rainfall up to 3,000mm in rain season, from April to October. Therefore farmers have no irrigation in this season. However, the terrain in this province is sloppy and it slides the areas into many small hills and valleys. The slope is from 0 to 30 degree. Along with this slope, the main rivers are divided into many branches of streams and run over many districts. Because here is the up-stream area, the branches are narrow and small, and they cannot store much water for irrigating in dry season. Therefore, farmers have to store water in ponds in their farm lands. Many farmers have small farms; they share land to use the same pond. Farmers have large lands; they have own ponds in their farms; and because the sloppy terrain, the small hills and valleys do not allow for large ponds to store more water. In the past, these ponds stored enough water for dry season. However, with the unpredictable climate change in recent years (DARD, 2013, 2014 & 2016), farmers need more water from other water sources, directly from streams or irrigation dams[3]. Specially, farmers are now thinking of using the ground water for their farms, because the local dams just support partly in some agriculture areas (DARD, 2014). In the study areas, irrigation dams just supported to 21.2 percent of farmers; 18.3 percent of farmers got water directly from streams; 56.6 percent of farmers used water from their ponds; and 3.9 percent of farmers used ground wells as the main water source for irrigation. Some of them (11.2 percent of farmers), because of difficult climate, used the extra sources for more water.

According to the guideline of DARD (2001), the water usage for coffee was 550 to 600 liters per tree per time, and four times in dry season. The average water usages in three studied areas were different. DakR'Lap and GiaNghia had nearly the same usage as the guideline, but Dak Mil was higher. Examining the water usage over 600 liters per tree per time in three areas, Dak Mil had 38.6 percent of farmers overused water. This ratio in GiaNghia was 34 percent and in

[3]The irrigation dams are developed by government as the large ponds or lake to store more water for dry season. However, because of the sloppy terrain, these dams are not large enough for much water.

DakR'Lap was 24.5 percent. The highest usage was 2,400 liters in GiaNghia (four times higher than the guide), 1,555 litters in DakR'Lap, and 1,600 litters in Dak Mil (two and a half times higher than the guide). Farmers had four times of irrigation along with four growing stages and fertilizer applications. However, because of the climate changes, DakNong has been suffered the longer dry season in recent years, they even irrigated 5 to 6 times in dry season to keep flowering.

Awareness of Water Source to Coffee Irrigation of Farmers

Linking the distance between the water sources to farm lands is to understand the farmers' awareness on water saving for future. The nearest distances mostly are ponds or ground wells in the farms; and the farther distances are streams of dams. In three studied areas, Dak Mil had the farthest distance, and then came DakR'Lap and GiaNghia. The nearest distance of water source in Dak Mil was about 50 meters; the average was 364 meters; and the farthest is 1,500 meters. In DakR'Lap and GiaNghia these distances were 10; 175; and 1,000meters; and 10; 178; and 600meters; respectively. With the second water source, GiaNghia had only one source, because its terrain is in the large plateau and the river branches in here are large; while Dak Mil and DakR'Lap are in the higher elevation and sloppy. Specially, in Dak Mil the irrigation dams just support for only 14.5 percent of the total agriculture area[4]. And because of small and narrow streams, and far distances of water sources, thinking of the limit water in dry season, farmers trended to use more water to keep in their farm lands.

However, most of farmers thought that this usage was just enough for coffee flowers and fruits (86.8 percent of farmers). They were aware of much water will harm the coffee tree and reduce the production. Some of them thought that following the guide the tree can grow well. Farmers who had their farms near water source, thought that water is available therefore they did not need to irrigate much water. Some farmers thought this usage still not enough for flowering and having fruits (8.4 percent of farmers), because of longer dry season, their ponds had less water and they had to irrigate more water from other sources. Few others thought that water was always available in rivers (7 farmers, 2.3 percent of total); therefore they overused water. This discussion showed the three groups of farmers' awareness: (1) Farmers followed the guide to be sure the growth of coffee tree even their farms near the dam or stream; (2) Farmers had farms far from water source trended to irrigate more water to keep in lands; and (3) Farmers had farms close to the stream trended to irrigate much water in dry season. In comparison to water usage above, many interviewed farmers thought their usages follow the guide, however; their water usages were much higher than the guideline.

Relationship of Water and Fertilizer Inputs to Coffee Production in Daknongprovice

Analyzing the relationship of coffee yield to the fertilizer usage, applied times of fertilizer, water usage, and times of irrigation, the result was described as the following Table 1 of coefficients:

[4]According to the DakNong Department of Sciences and Technology, Dak Mil has total 37,000 hectares of agriculture area. In which, coffee area is about 22,000 hectares. And the irrigation dams developed by local government in this district can just irrigate for only 14.5 percent of total. The information gathered from the website of DakNong Department of Sciences and Technology: http://skhcn.daknong.gov.vn/tin-tuc-su-kien/hoat-dong-khcn-cua-tinh/1696-he-thong-thuy-loi-dak-mil-hien-trang-va-giai-phap ; retrieved on 4th April, 2017.

Table 1: Coefficients Summary – Relationship of Robusta Coffee Production per Crop to Fertilizer Usage, Water Usage in Dry Season, Applied Times of Fertilizer, and Irrigation Times in Dry Season

	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	4.154	.764		5.435	.000		
N,P,K usage per crop	.808	.063	.572	12.811	.000	.623	1.606
Water usage in dry season	.002	.000	.352	8.167	.000	.670	1.493
Applied times of N,P,K	-.813	.156	-.193	-5.217	.000	.908	1.102
Irrigation times in dry season	-.437	.203	-.076	-2.148	.033	.992	1.008
R square = 0.641, Adjusted R square = 0.636, Std. error of the estimate = 1.99138, and Durbin-Watson = 2.025							

Source: Result analyzed from the field survey

Then the equation of dependent variable of yield production could be written as follow:

Y (coffee yield) = 4.154 + 0.808 X1 + 0.002 X2 – 0.813 X3 – 0.437 X4

Where: **X1:** N,P,K usage per crop

X2: Water usage in dry season

X3: Applied times of N, P, K

X4: Irrigation times in dry season

The results showed the inputs of fertilizer and water made the fluctuation of coffee production. It can be seen that when increasing of N, P, K usage the yield will increase. The standardized coefficients showed the more water usage the less increase of coffee yield. And specially the more times of N, P, K application and irrigation the decreasing of coffee yield (Bennett *et al.*, 2009; and Winston *et al.*, 2005). Because the more fertilizer application the more coffee yield, farmers trend to use more fertilizer to have more yield. This brings more land degradation and water pollution to this area and brings later to the downstream areas. Therefore, the technical advisement for coffee plantation is really necessary to farmers to save more water and fertilizer. Reduce inputs can reduce investment costs.

Climate Change and Limitation Water Impact to Coffee Irrigation

Asking about the changes of water source during the last five years in dry season (including water sources in ponds, streams, dams, and ground wells) many farmers said the water was being shortage in their ponds (60 percent of farmers). Water in streams was decreasing as well. The local government stores water in dams for irrigating. In dry season, water is pumped by the government from the rivers or streams into these dams. Therefore, asking about the water source of dams, most farmers said that this source is still available. However, the report form DakNong DARD (2016) said many dams were completely dried in last April 2016. To the ground water, farmers had not much information on ground water; just few of them used ground water for their farms. And about water shortage in the near future (within next five to ten years), 85 percent of farmers thought that fresh water from rivers and streams and ground water will have problems. In which, 40 percent of farmers believed these sources will be seriously decreased, and other 45 percent of farmers thought these sources will be just slightly decreased in the near future. However, they thought that many farmers trends to use more ground water because of water shortages in ponds and streams. Therefore ground water will have problem in the near future.

When discussing about the reasons of water shortage, most farmers said that the main reason is the increasing temperature and it makes the dry season longer in the last five years (97 percent of farmers). This resulted in the coming late of rain and farmers had to irrigate more in the end of dry season. They also thought that the temperature would be increasing and would impact more on water sources (95 percent of farmers). To evaluate the farmers' awareness of climate change, the climate data report from the DakNong Center for Hydrometeorology (2013) showed the same conclusions with the increasing of temperature, decreasing of rainfall, and slightly increasing droughts. Other reason of water shortage was the increasing of deforestation (24.2 percent of farmers).

Irrigation System and its Development Plan

According to the DakNong DARD reports (2015 a&b), DakNong province has total of 213 irrigation works. In which, there are 4 pumping stations, 17 dams, 186 lakes, and 6 canals. The system can irrigate over 40,110 hectares of agriculture, including 85 percent of rice fields; 35 percent of coffee, pepper and other agricultural areas. Amongst these works, many of them have been degraded by long time of using (DakNong DARD, 2015b). However, the changing of climate recent years has caused the prolonged dry season and impacted on many agricultural areas (DakNong DARD, 2013&2016). Many lakes exhausted water or unavailable for irrigation last year (DakNong DARD, 2016), and destroyed many crops of coffee, pepper and rice, and others. The rest agriculture areas without dams, farmers irrigated from their ponds, directly from streams, or from ground water.

As discussing above, where dams had been developed near the farm lands, farmers trended to apply water usage as technical advisement. Other locations without dams, farmers trended to overuse water. Therefore with such irrigation system, DakNong province has wasted much fresh water per year. And with the unpredictable changing of climate, most farmers thought that the technical advisement issued by MAR (2001) is not enough information, or out-of–date, for their crops (93.9 percent of farmers). They need more advices from the agriculture extension workers, however; these local officials have not ability enough or lack of technical knowledge to support to farmers (said by 53.7 percent of farmers). The irrigation system in this province is incomplete, though; very few farmers (4.5 percent of farmers) suggested government should upgrade this system. Most other farmers did not consider. They use fresh water from streams instead of waiting dams, because most water in dams come from streams and they have also less water in dry season.

CONCLUSIONS AND SUGGESTIONS

The special typology and climate cause the problems of water usage to coffee farming in this province. Rain is concentrated in rain season. The upstream areas of two main rivers keep less water storage for the dry season, because of small and narrow branches. And the sloppy terrain supports less for the large farm size and the large irrigation works. Many people cultivated in small land, therefore they planted with high density, applied more fertilizer, and irrigated more water to have more yield. The climate changes cause the longer dry seasons; farmers used more water to keep flowering and having more fruits. The linear regression showed the increasing of yield when increasing fertilizer. But the more water used, the yield trended not to increase. And the increasing times of fertilizer application and irrigation did not support to coffee production. Because of yield increased, farmers trended to apply more fertilizer and as well irrigate more water. For every one time of irrigation, the water usage was much higher than the advisement and caused much water loss. The far distance of water sources drove farmers to irrigate more; while the local irrigation system has been partly degraded and incomplete. With the unpredictable changing of climate, the technical advisement is not enough information to guide

farmers.

Government should update a new technical guideline of coffee plantation by developing more researches and systematically climate data gathering to advise the suitable water usage to farmers in the special situation, develop the complete irrigation system to control the water usage, strongly control the fertilizer and chemical application to protect land and water resources, strongly control the immigration and deforestation, and build the capacity of local agriculture extension workers to support better coffee farmers.

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